RESULTS OF SPACE SHUTTLE FLIGHT 51-D

HEARING

BEFORE THE

SUBCOMMITTEE ON
SPACE SCIENCE AND APPLICATIONS

OF THE

COMMITTEE ON
SCIENCE AND TECHNOLOGY
HOUSE OF REPRESENTATIVES

NINETY-NINTH CONGRESS

FIRST SESSION

MAY 3, 1985

[No. 19]

Printed for the use of the
Committee on Science and Technology

U.S. GOVERNMENT PRINTING OFFICE
WASHINGTON : 1985

48-813 O

H701-80

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CONTENTS

WITNESSES

Page

May 3, 1985:

Col. Karol Bobko, mission commander of Space Shuttle Discovery Flight 51-D 5

Dr. Rhea Seddon, mission specialist on Space Shuttle Discovery Flight 51-D 7

RESULTS OF SPACE SHUTTLE FLIGHT 51-D

FRIDAY, MAY 3, 1985

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS,
Washington, DC.

The subcommittee met, pursuant to notice, at 10:30 a.m., in the Wright Music Building Auditorium on the campus of Middle Tennessee State University, Murfreesboro, TN. Hon. Bill Nelson presiding.

Present: Representatives Nelson and Gordon.

Mr. NELSON. The meeting of the Space Science and Applications Subcommittee will come to order.

I'm Bill Nelson, a Member of Congress from Florida. I have the privilege of being the chairman of this subcommittee.

Bart Gordon is one of our most enthusiastic members of this subcommittee, and so we are delighted to come to Middle Tennessee today to have this as our first time that Congress has had a field hearing where we have had the official report of an astronaut crew to the U.S. Congress.

Normally, that is an occasion after each shuttle flight that is done in our committee hearing room in Washington. But we decided on the occasion that both Rhea and Bart are from Middle Tennessee that we would just come here and have this official presentation to the Congress and have it out in the country, instead of in the Nation's Capital. So, we're delighted to be here. We're delighted with the hospitality that you all have extended to us.

I just had the privilege of sharing with Colonel Bobko and Dr. Seddon, with several students, a little earlier this morning. And the questions are sharp, the enthusiasm is high, and the perception is deep.

So, we are going to proceed with our hearing here.

Now, the fact that the university would let us use these facilities, we appreciate it; we're looking forward to the rally a little later on today.

This committee, our overall Committee on Science and Technology and our Subcommittee on Space, has held these hearings after each manned space flight in the committee room in Washington. If you all were participating there with us, you would see, on the walls, pictures from each of the space flights, going back to the time of the Mercury program, when America put its first man in space.

Do you remember that time—in the late 1950's—the Soviets had put up Sputnik—they beat us. All the Nation came together. We

decided that we were going to forge ahead. We had a national commitment, and we did it.

And then the Soviets beat us with the first man in space, Yuri Gagarin. But shortly thereafter, we put up Alan Shepard in suborbital flight, and then Gus Grissom, and then the first American to orbit the Earth, Astronaut John Glenn, now U.S. Senator from the State of Ohio.

So, we had that commitment, we've had that national will. And that national will was translated through the leader of this Nation, President John F. Kennedy, when he said, in the early 1960's, soon after he had taken over as President of the United States, that "this Nation is going to land a man on the Moon by the end of the decade and return him safely." And we did that in 1969, with the crew of Armstrong and Aldrin and Collins.

Now, today's hearing, we're going to have testimony from two witnesses: Col. Karol Bobko, who was the mission commander for the flight that we're receiving the report. It's called "Flight 51-D." It's the 16th flight of the space shuttle.

And Dr. Rhea Seddon—all of you here know who Rhea is, because she grew up right here. She was a mission specialist, as a medical doctor for the flight.

It was particularly impressive in this flight that the crew in space and the teams on the ground were so quickly able to respond to an unforeseen problem and then to work that problem and to come up with all kinds of innovation in which to try to get that switch to activate on that malfunctioning Syncom satellite.

Well, the crew's efforts were flawless. And when I speak of "crew," I'm speaking generically. It's not just "those guys"—and that's a generic term, too; right? It's not just "those guys" up there in the shuttle, but the crew is very much that ground crew which is in constant communication working out the problems on the ground and trying to execute that across hundreds of miles through space, as they are communicating, trying to work it out.

Now, obviously, there was something wrong with that satellite besides the switch, because they maneuvered the shuttle over there, they put together that fly swatter, went out there on an EVA, what's called the "Extravehicular Activity," attached it to the shuttle robot arm. Rhea was operating that arm absolutely flawlessly—went on over there and moved that switch. It didn't start the activation on the timing mechanism. But that in no way diminishes the success of the crew.

To the contrary—they had to adapt to a new situation, and they did it perfectly. And we're looking forward to getting the details of those particular innovative procedures.

Now, my Republican colleague, who is my ranking Republican member, Bob Walker, from the State of Pennsylvania, had a speech back in his hometown that was scheduled long before. And he could not be with us today. He sends his regrets to you.

And at this point, normally I would turn to Bob Walker and ask for any comments and his opening statement. But now it's going to be my pleasure to turn over—so that he can chair this meeting—Bart Gordon.

I can't say enough to you all about what a terrific Congressman you have. His enthusiasm is contagious. His work is exemplary.

And on top of all that, he's a good personal friend, who has helped me, as chairman, very much in our duties.

He is a topflight member of our committee, who has America's space program right at first in his heart.

And so I want to take this gavel, the sign of authority of the chairman, and turn it over to Bart and ask him to chair the meeting.

Mr. Congressman.

[The prepared opening statement of Representative Nelson follows:]

OPENING STATEMENT OF HON. BILL NELSON

I would like to open this hearing by stating what a pleasure it is to be here in Murfreesboro and on the campus of the Middle Tennessee State University. I am especially appreciative of the warm hospitality that has been extended to us since we arrived last night. It is clear that the tradition of "Southern hospitality" is alive and well in Middle Tennessee.

Throughout the history of the U.S. space program, the Committee on Science and Technology has held a hearing such as this after each manned space flight. These hearings provide an opportunity for the Congress and the people of the United States to learn the results of each mission on a first-hand basis from the crew who made the flight.

Until today, these hearings have always been held in Washington, DC. Therefore, they have only been readily accessible to people who live in or near the Nation's capital. Congressman Gordon and I thought that now would be a great opportunity to make available to Americans in another part of the country a chance to hear more directly about the space program that they help pay for through their taxes. Accordingly, we have moved this hearing from the halls of Congress to the hills of Middle Tennessee.

At today's hearing we will receive testimony from two witnesses—Col. Karol Bobko, the mission commander for 51-D (the 16th flight of the Space Shuttle) and Dr. Rhea Seddon, who served as a mission specialist on this flight.

During this mission, I was particularly impressed with the manner in which both the flight crew in space and the teams that were supporting it on the ground were able to so quickly respond to an unforseen problem and generate and implement contingency plans to resolve it. The crew especially is to be commended for the perfection with which it executed the attempts to activate the malfunctioning Syncom satellite. The crew's efforts were flawless. Unfortunately, the problem with the satellite appears to be something different than a switch that was not fully activated. But in my view, this in no way diminishes the success that the crew had in perfectly executing its rescue attempt. We look forward to hearing the two members of the crew that are with us today describe the innovative procedures that were used to try to save the malfunctioning Syncom satellite.

It is my understanding that there is no minority statement for the record today. In that case, we will proceed.

Since we are holding this hearing in Bart Gordon's district, I thought that it would be nice to extend him the opportunity to Chair the rest of these proceedings. So, without further ado, Bart and I will change seats so that he may preside over the rest of the hearing. Bart . . .

Mr. GORDON [presiding]. First of all, let me thank Bill Nelson. He was the one that arranged for us to come to Murfreesboro. And without his help and leadership, we would never have been able to do it.

And as Bill said, this is the first time that we've been able to go outside of Washington for this type of meeting, and I think it is a good precedent. I think that we need to take the message outside of Washington. All of you can't always come there, and we need to be going to the people.

And let me say, too, very quickly—and I guess personally—that Bill is one of the first Members that I met when I went to Wash-

ington, as your Congressman. And it was interesting that Bill had the audacity to run for chairman of this committee against a senior member, and that's something you just don't do.

And more than that, he won. And since that time, he's won the respect of everyone on the committee and the staff for his enthusiasm and the good work that he did. And I'm proud to have him here in Murfreesboro and a part of this.

I want to thank Dr. Ingram for allowing us to come on short notice to MTSU and for all the work you've done in getting this together.

I also want to thank everybody in the audience that took time out of your busy schedule to be here. It's not often that we have a congressional hearing in Murfreesboro, and I suspect that a good many of you are taking this opportunity to check up on your Government and to find out just what do we do in Washington and to see that your tax dollars are being spent wisely. And I don't think you're going to be disappointed. In fact, I hope that you'll be proud, as I am, of the achievements of our national space program.

Today I'd like to focus for just a moment on the economic potential of space and the return that we're getting for our investment.

It's interesting to note that for every dollar that is spent in NASA research and development, it returns slightly over $7 to the gross national product. And I think that's a good return on our investment.

The possibilities offered by space are enormous. The development of space holds such great potential, that it's really difficult to find comparisons.

I believe those pioneers that are leading us into space are similar to those that pushed the railroads across the mountains and across the plains, until the system spanned from the east coast to the west coast.

In what is rapidly becoming an age of limits, space offers a new and boundless frontier for exploration, growth, and challenge.

The space industry, although still in its infancy, now generates about $23 billion a year. The first success story has been the space communications satellite system. That industry, which was pioneered by NASA, now does more than 3 billion dollars' worth of business annually and employs more than 1 million people.

Our shuttle program is paying dividends daily in the areas of pure research as well as space commercialization.

And as we look to the future, I believe great economic potential lies in manufacturing in space. The near weightless, ultra-clean environment of space makes it ideal for the production of many materials. In fact, a new process for drug manufacturing was tested on this flight that we'll discuss today. Also being tested, on other shuttle flights, are new methods for producing everything from crystals that you'll find in your watch to new, stronger metals that we can use in farm equipment.

It's the obligation of Congress to design a comprehensive strategy which will preserve our leadership in the space program. We have a duty to support NASA in the job that they're doing so well.

Today I want to present to you Comdr. Karol Bobko and Dr. Rhea Seddon for their presentation. [Applause.]

[The prepared opening statement of Representative Gordon follows:]

OPENING STATEMENT OF CONGRESSMAN BART GORDON

First, I would like to thank the chairman of the subcommittee, the Hon. Bill Nelson of Florida, for arranging this hearing in Murfreesboro. This day holds special significance for many of us. I appreciate your efforts on our behalf.

I'm glad to see that so many of you took time out of your busy schedules to join us today. It isn't often that we have congressional hearings in Murfreesboro and I suspect that a good many of you are taking this opportunity to check up on your Government, to find out just what it is we do in Washington, and to see that your tax dollars are being spent wisely.

I don't think you will be disappointed. In fact, I hope you will be proud, as I am, of the achievements of our National Space Program. Today, I'd like to focus for a minute on the economic potential of space and the return we are getting on our investment.

It is interesting to note that every dollar spent on NASA research and development returns slightly over $7 in benefits to our gross national product. I think that is good return on investment and one in which NASA and Congress may take pride.

The possibilities offered by space are enormous. The development of space holds such great potential that it is difficult to find comparisons. I believe those pioneers who are leading us into space now will bring the same economic boost to our Nation as those who once pushed the railroad over mountains and across the plains until the system spanned from the east coast to the west coast.

In what is rapidly becoming an age of limits, space offers a new and boundless frontier for exploration, growth and challenge.

The space industry, although still in its infancy, now generates about $23 billion per year. The first success story for space commercialization has been satellite comunications. That industry, which was pioneered by NASA, now does more than 3 billion dollars' worth of business annually and employs more than 1 million people.

Our shuttle program is paying daily dividends in the areas of pure research as well as space commercialization.

As I look to the future, I believe that great economic potential lies in manufacturing in space. The near weightless, ultra-clean environment of space makes it ideal for the production of many materials. In fact, a new process for drug manufacturing was tested on the flight we will discuss today. Also being tested, on other shuttle flights, are new methods for producing everything from crystals for your watch to a new stronger metal for farm equipment.

Cost-effective manufacturing will demand a cohesive system of space stations and orbiting platforms, as well as launch and repair services. Private firms build these space craft. They then launch them and help process and analyze the data they gather. This will continue to create more and better jobs into the next century.

It is the obligation of Congress to design a coherent strategy which will preserve our leadership in space development. We have a duty to support NASA in the job they do so well.

STATEMENT OF COL. KAROL BOBKO, MISSION COMMANDER OF SPACE SHUTTLE "DISCOVERY" FLIGHT 51-D

Colonel BOBKO. Congressman Gordon, Congressman Nelson, people of Middle Tennessee, the fourth launch of the orbiter *Discovery* and the 16th launch of the shuttle series took place at 8:59 on the 12th of April.

You notice I didn't say "our launch," because I don't want you to feel that it's our shuttle or the Government's shuttle, but it is, rather, the shuttle of the United States. And I think we can all be proud of it.

The flight was planned, as they told me, to be rather routine, with only the launch of two proven satellites, continued operation of the continuous-flow electrophoresis experiment, investigation with an echocardiograph, student experiments, gas canisters, nine detailed test objectives, and planned Earth observations. That may

all sound like a routine flight compared to other NASA missions, but as my first command, that certainly sound like an ambitious program.

The crew of the *Discovery* of this flight consisted of my pilot, a Navy captain, Don Williams; mission specialist Jeff Hoffman; Dave Griggs, and you all know Rhea Seddon.

And then we had two payload specialists, Mr. Charles Walker from MacDac and Senator Jake Garn.

The NASA members of the crew had trained together since September of 1983. That sounds like a long time, and it was. We had been scheduled for two other missions that were canceled or somehow combined. When we did fly, however, we were trained to do about anything. And as it turned out, we were asked to do about everything. During the flight, I was confident that we could do all the tasks that were proposed. We were trained to do them.

But looking back at the flight, I am amazed at the professionalism and maturity of all the people, both on the ground and my crew in space, and how they were able to bring together this long string of complex, precise, and previously unplanned actions that resulted in our attempt to activate the Syncom satellite. As you know, our attempt at activation was unsuccessful. However, we did get valuable data and photographs that are the basis for planning a revisit to that satellite, and we hope to be able to have it activated during another mission.

We have prepared a small film, and we'd like to show it to you. And I think it will describe quite well some of the activities that took place during the flight.

Would you please start the film. [Film shown.]

This is our patch, the *Discovery.*

And we said that the flag around the Earth showed the preeminence of the U.S. Space Program.

Here we are going out to the launch, the morning of launch—myself, Don Williams—there's Rhea, Jeff Hoffman, Charlie Walker, Jake Garn, and Dave Griggs.

It's quite strange going out to the orbiter in the morning because nobody is around when it comes time to launch.

These are the hydrogen burners, and the engines are getting ready to ignite. And you'll see them ignite—one, two, three—and then the solid motors start. They're stable, producing about 1 million tons of thrust. The vehicle is still held down at this point. And then finally the solids ignite and we're off. When you're still close to the ground, there's still quite a reflection of shock and vibration back into the vehicle.

This is slow motion. It really seems to just leap off of the ground.

Once you're clear of the tower, the roll program begins, and the vehicle is pointed down range in the plane of its orbit. You get to Mach 1 at about 19,000 feet. And, of course, 2 minutes into the flight, the big solids are expended and finally drop off, 2 minutes into the flight, you're over 25 miles down range, and you're over 25 miles in altitude.

It's quite a ride. [Pause.]

There's about 7 million pounds of thrust being generated at that time. We went into the clouds about 10,000 or 12,000 feet and came out about 33,000 feet.

STATEMENT OF DR. RHEA SEDDON, MISSION SPECIALIST ON SPACE SHUTTLE DISCOVERY FLIGHT 51-D

Dr. SEDDON. Our first satellite deployment. [Continuation of film being shown.]

This is the Anik satellite for Canada. It's a communications satellite. The deployment went completely nominally. This is a spin-stabilized satellite, in that it rotates in this direction as it comes out of the cargo bay. There it is, silhouetted against the Earth horizon. It is a very pretty deployment, in that you get to see the Earth in the background.

This satellite will be actually stored in orbit. It was much less expensive for Canada to launch that satellite today and store it in orbit, rather than storing it for 3 years or so here on the ground and launching at a somewhat later date.

This is the Syncom satellite. It's a "Frisbee" deployment—is how we describe it. And it comes rolling out of the cargo bay. That's about 7½ tons worth of satellite.

You can see the white antenna on the top that was supposed to pop up about 80 seconds after the deployment. The deployment was completely nominal. We had no reason to suspect that there was anything wrong with this satellite as it came out of the cargo bay. About 80 seconds later, when we expected to see the omni-antenna deploy, it didn't. We all looked at our watches, we all looked at our checklists and said, "Something is not right."

We watched it for about 6½ minutes to see if it would begin its spin-up. It spins to a much higher rate of revolutions per minute. But it didn't happen, and so we fired our separation motors. And this is what it feels like when those motors ignite; it's quite a jolt when you're just floating around.

And that's the tail-off of the burn and some of the smaller jet firings. It's rather spectacular to look at against a dark sky.

We watched it carefully, hoping against hope that it would begin its activation, but it never did while we could see it.

This is one of our middeck experiments. I'm taking my blood pressure, in conjunction with the American flight echocardiograph machine.

This is Senator Garn. His primary responsibility on the shuttle was in overseeing NASA's work and seeing how the Shuttle Program was put together. But he also volunteered for a number of medical experiments. He has told us that he thought he was particularly suited to this experiment because it required electrodes on his head. And since he doesn't have any hair up there, it was easy for him. [Laughter.]

This, again, is the American flight echo. That transducer emits sound waves and reflects them off internal structures and then receives the echo back in that transducer and produces a two-dimensional picture on the screen. It is the first time that Americans have been able to look inside the human body and, in a safe and reliable way, determine what is going on in the heart and the major vessels inside the heart—inside the chest, seeing how fluid redistributes. That's a picture of my heart. The little flapper in the middle is the mitral valve, and that's my left ventricle beating.

We were able to gather data on four different crew people, and that's now being analyzed to see the differences in volume in the heart and the difference in heart rate and resistance to peripheral flow.

This is Charlie Walker, who ran the continuous-flow electrophoresis experiment. This is an experiment that takes materials and puts them through a column of fluid and separates them based on their electric charge. You're not able to do that well here on the ground, because gravity interferes and sets up flow currents through the liquid and so they're not able to get very high concentrations here on the ground. Johnson & Johnson is doing the chemical work and McDonnell Douglas is doing the engineering work on this experiment.

Charlie, at this point, is analyzing some of his product. They are looking at different hormones, different proteins, different medications—even separation of cells.

He analyzed this time for any bacteria that might be growing in his system, because last time they had some contamination. He has given us every indication that there was no contamination problem on this flight, and they're hoping to give this material to the Food and Drug Administration to test for purity and potency and hope to produce on a commercial basis in the future on the space shuttle.

Colonel BOBKO. This is Jeff Hoffman, and he was showing here that one of our pairs have gyrostabilized binoculars. It really wasn't as stable as we had thought. [Laughter.]

There are all ways to look at things in space that you never think of on the ground. One of the things we were asked to do before we flew was to look at some toys. And so we took a bag of toys with us to be used for scientific purposes so that we could make films and show them to students.

Here I am with a gyroscope, and the gyroscope has not been spun up. And so you can see that it tumbles quite easily with just a little touch of my finger. After I demonstrated that, then I spun it up—and it's just a normal kid's gyroscope—and now you can see that it has significant stability. You can push it around with a string, I can touch it with my finger, and it still retains its orientation in space. Of course, that's why we spin-stabilize satellites. That's why for hundreds of years we have spun-stabilized bullets. We call them rifles. And that means that the object will retain its orientation in space. We use that significantly in the spacecraft. We have many gyroscopes that allow us to have some reference for attitude.

I also had a small top, but we don't have a film of that in this clip now. [Pause.]

Here's Jeff Hoffman with his "wheelie," and he's showing that that can also be used in space. You can't imagine the discussions we had about whether some of these simple toys would work there. And even some rather learned physicists had discussions about how they would behave. But now we've brought back some data—well, here is one——

[Laughter.]

Colonel BOBKO [continuing]. The yo-yo.

We had more discussions about whether a yo-yo would work. And as you see, it worked quite well. Dave got rather proficient with it. [Laughter.]

He could do just about anything with it. The only thing that I wouldn't let him do is use it on a flight deck.

Dr. SEDDON. Here are the jacks and ball that I took. I found that the major problem with jacks in space is that you couldn't get your jacks to stay in the same place. And you had to chase them all over if you weren't careful. The ball hit the jacks, the things went spinning all over the place.

This is Senator Garn's experiment, a paper airplane. You can see that, without any force applied, it drifts in the air currents that we have. And it won't go anywhere really. We wondered whether it would fly. It does. It gives a nice aerodynamic job if you give it a little push. It doesn't fly backwards very well at all. So, it is using its aerodynamic shape.

This is a paddleball. It worked pretty much the same way up there, except you could do it much more slowly. It did still have the same elastic features that it had here on the ground. And Don enjoyed it. There were a few things that he did that you couldn't do on the ground, and I think one of them is coming up here shortly. But that one acted pretty much like it does, except maybe when you let it go. [Laughter.]

He found that he could paddle without holding onto the paddle.

We did these experiments so that we could show the properties of these toys and show how gravity affects playing.

This was a fascinating piece of equipment. Jeff had taken some magnetic marbles. They tend to form circles and float in the air, and you can float other marbles into them. Sometimes the marbles will float in and join the circle. At other times the marble simply passes by or sticks on the edge. And exactly why it does that, we're not sure. But it's very interesting.

Coming up, you'll see some demonstration of how a magnetic field passing close by will change the way the thing is floating. And so it disturbs the orbit of these magnetic marbles.

This is our mascot, Ratstuff. That's a flipping mouse. We named him Ratstuff.

This is the "Slinky," that we thought was going to be fascinating in zero G, but it did pretty much the same thing in space as it does here on the ground. The only thing it would not do is it would not slink; you could not get it to jump from one step to another. But it made some pretty pictures of sign waves and different modes that you could set up.

This is a car that runs on a track. And as you know, here on the ground, a car like this will run on the track till it runs out of steam, and then it will slowly stop—down at the bottom. But this one does something just a little bit different. [Laughter.]

So, we had a lot of fun with the toys.

But then we had to get down to work. The teleprinter message came up the next morning that said "Instructions on How to Build a Fly Swatter." We were a little worried about it, because it was a fly swatter that had three large holes in it. And we weren't sure how we were going to swat flies with a fly swatter like this. It was not clear to us at this point exactly what we were going to do with

the two fly swatters that we had been instructed to make. One looked more like a fly swatter; the other looked more like a lacrosse stick. And so they became known as the "fly swatter" and the "lacrosse stick."

That's Senator Garn, who was very helpful during all this, putting this fly swatter together. It's a heavy piece of equipment there.

Colonel BOBKO. We had to take the fly swatters and attach them to the manipulator arm, so that required an extra vehicular activity, a space walk.

And here is Jeff getting into the lower torso, the space pants. And you can see that in space you can don your trousers two legs at a time. [Laughter.]

It's a lot easier to do it in space than it is on the ground. However, the suit is rather large and bulky, as you can see. Naturally, this is a suit that has been developed over many years of space flight. And we have found ways to make it easy to put on and quite mobile once you are out in the bay.

Those are the two finished products—as we call them, the "fly swatter" and the "lacrosse stick."

I was the valet. I was the one who got them dressed. And so here's Dave on the right, and then Jeff will go on the left in the picture. And we're putting them into the suits. [Pause.]

Those pipes you see there are cooling water, which keeps the people cool in the suits, and biomedical instrumentation.

Dr. SEDDON. They were very happy about getting to do an EVA. They didn't think they'd get to do it. Luckily, there were enough of us on board that somebody could always be taking pictures. And we brought back some interesting film, I think you'll agree.

Colonel BOBKO. One thing about working together as long as we had was that we had kind of developed a rapport and a sense of humor. And it made working together on orbit very pleasurable.

Here they are outside, attaching the "fly swatter" and the "lacrosse stick" to the large arm that Rhea had at this time brought over to the right side of the orbit so they could work there. You can see how large the payload bay is in relationship to the two men, who are dressed in these very large suits.

What you see to the right is the Sun shield, a little covering to protect the satellite from the Sun. And those two canisters are getaway special canisters; they're small experiments that people put on board the shuttle. And they require a rather small interface with the crew, and yet they can get some valuable scientific data out.

This is taken from a camera that's located in the aft part of the shuttle, and it shows exactly how they're taking a large strap and strapping those two items to the large manipulator arm. You can see that they have no connection to the shuttle except the very small wire—we call it a tether. And all of their atmospheric support, all of their cooling, all of their communications comes from those two backpacks that they're wearing. They said it's quite a view out there. You don't have a window. You seem, with that large faceplate, to be right out in space. And it really is even a more fantastic view than we see from the inside of the shuttle.

People ask me—they say, "Well, does it look like the pictures in space?" And I say, "Yes, in about the same manner as a picture of the Grand Canyon represents standing on the north rim or the south rim."

Of course, people on the ground had done this in the water tank before we ever attempted it in space, and the crew on the ground had developed the procedures, put them up to us in teleprinter form, which is kind of a typewritten page, and also spoken to us on the radio, so that we knew exactly what to do. And then they were able to get the television down of what we were doing and correct any mistakes that we had made or discuss with us changes that we had proposed.

I think that the combination of us in the air, being supported by the people on the ground, is just unbeatable. It gives you a lot of confidence that somebody has thought about this. When they speak to you on the radio, it's obvious that they have tried it before they want you to try it on space.

Both Jeff and Dave worked well in the suits. They had a lot of practice on the ground. And even though this was a totally unplanned EVA, they did a superb job.

You can see just a little of the ocean going by below and the small clouds that are there. [Pause.]

Of course, the big item in EVA is to keep yourself stable. There is even less stability than there is in water, because you don't have the viscosity of the water to react against. So, you have to work slowly and deliberately.

Here's Rhea with the arm. She put the arm down where it is normally stowed, to check to make sure that the doors would close, even with those items attached to the outside—attached to the RMS.

And here's Jeff now, coming back at the end of the EVA. [Pause.]

The payload bay is large. You could take a whole bus and put it in the payload bay and still have room.

Once we were finished with attaching those items to the arm, then we were ready to start the rendezvous. This is Don Williams in the foreground, and I'm there in the background. We hadn't done a rendezvous because one wasn't planned in this mission. We hadn't practiced one in about 7 months. And so they had a teleprinter up—all of the procedures for us. But we were finally able to make the rendezvous. And here we—this is a zoom-in. We don't actually approach the satellite at that speed. And here I am, during the final portions of the rendezvous.

We had to get up very close so that Rhea could reach the satellite with the arm. We had to get up to within about 30 feet of the satellite. That's rather amazing, considering that you're both traveling at about 26,000 feet per second. It's rather amazing to be able to find something out there in the vastness of space. [Pause.]

If you look very closely, you can see the plunger. It's the silver thing up in the middle a little lever down in the right-hand corner. That's what Rhea was going to be getting with the RMS.

Dr. SEDDON. The remote manipulator system is, of course, operated from this aft station, using out-the-window views and TV cameras. There was some question as to whether the arm and its oper-

ator could get up close to this huge satellite and snag that lever within the timeframe we had. There is one hit. [Pause.]

Again, putting it softly against the satellite and trying to snag that little lever as it goes by. There's another good one with the fly swatter. And then they said, "Hit it with the base of the cone if all else fails." So, we moved the cone in very carefully and hit it one more time. We know of at least three attempts and three good hits on the satellite.

After we had completed that window, since we thought we might have activated the satellite, at the end of 6 minutes and 20 seconds Houston announced that the window was closed, and we backed away from the satellite, we separated from it—again, hoping that it would activate. It did not appear to. And all we can say is that we hope some of our friends will be able to go and perhaps resurrect it sometime in the future. [Pause.]

Colonel BOBKO. Of course, this is not all that happened on the flight, but that's all we have in the film.

We fired our engines over Australia, or west of Australia, hit the atmosphere around Hawaii. And then these are the shots as we were coming over Florida. The shuttle flew solidly, the day was beautiful. Even though we had delayed one orbit to wait for the weather to get better, everything was perfect for the landing.

At this point, we're coming over the coast of Florida and making the turn-in to get lined up with the runway. The shuttle had been on autopilot down until about that time. At that time, I took over control at about 40,000 feet and flew it from there down to the ground. Here we are on the final approach. A normal airline approach is 2½ to 3 degrees. We come down a 19-degree glide slope. [Pause.]

So, things happen quickly. Luckily, we have a lot of training devices, including an aircraft that flies like the shuttle. [Pause.]

Here we are coming over the Banana Creek, starting to break the descent so we can touch down softly. The gear is coming—you might just notice those little black spots at the bottom of the orbiter. Here comes the runway. [Pause.]

And it's amazing, after 109 orbits, after starting the descent over Australia, that you're able to touch down within a couple of feet of the planned touchdown point.

There was some crosswind that day, and we have had some problems with the tires, the wheels, and the brakes on the orbiter. And it looked like, because I was holding right brake so that the crosswind wouldn't blow us off the left, that the right brake overheated. And as you see here, a little bit later on, that caused the tire to overheat. And after we had come to essentially a complete stop, the heat soaked back into the tire and caused it to blow. It soaked back into the brake, caused it to lock up, which caused the tire to blow. Luckily, there were absolutely no control difficulties during the landing. We felt and heard the tire, but I had no problems keeping the shuttle right on the center line. And we stopped with somewhat over a half of a mile of runway left to go. [Pause.]

After the landing, it takes a few minutes for us to get the shuttle safe. And then they bring up the ladder.

And I think you can see the size of the smiles on our faces.

After my first flight, my wife said it took about 3 weeks to get me to quit grinning all the time. [Laughter.]

And of course, she says, if you ever turn my switch, I just ramble on and on and on about space flight. But it is a unique, challenging, and very beautiful experience. [Applause.] [End of showing of film.]

One thing we weren't able to show you—and that is some of the views of the ground.

And we'd like to ask for the slides and just show you a few slides to give you an idea of some of the things we're able to see from space.

Please show the slides (fig. 1).

FIGURE 1

That's a Sunset. We saw them every 92 minutes. And they're just gorgeous. That's one of the things that everybody remembers. After my first flight, I had that put on a Christmas card and sent it to all of my friends, because, to me, it was such a touching item. However, it has scientific value. Jeff, through binoculars, was able to count more than 20 layers of the atmosphere while looking at the setting Sun, and everybody is interested in those layers of the atmosphere and how they may change over the years of human observation while we have men in space.

The next slide, please (fig. 2).

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FIGURE 2

I think you may be able to focus it a little better.

This is the Great Barrier Reef off Australia, and the picture just doesn't quite catch all of the color and beauty that you see in the actual—when you're actually looking at the scene.

The next slide, please (fig. 3).

FIGURE 3

And as you can see here, this is the Sinai Peninsula. In the upper left-hand corner is the Nile delta and the Gulf of Suez and the Suez Canal. To the right is the Gulf of Aqaba, leading up to the Dead Sea and the Sea of Galilee.

You can see how much of the land you can appreciate from space and also, in this case, the atmospheric dust and haze that's over the Middle Eastern countries, something that scientists are very interested in documenting. So, first, the geologists, of course, are interested in photographs like this, because they can get a broad overview of what the geologic land forms are like and then, second, the atmospheric scientists are interested because they can see what sort of pollution may be in the air.

The next slide [(fig. 4)].

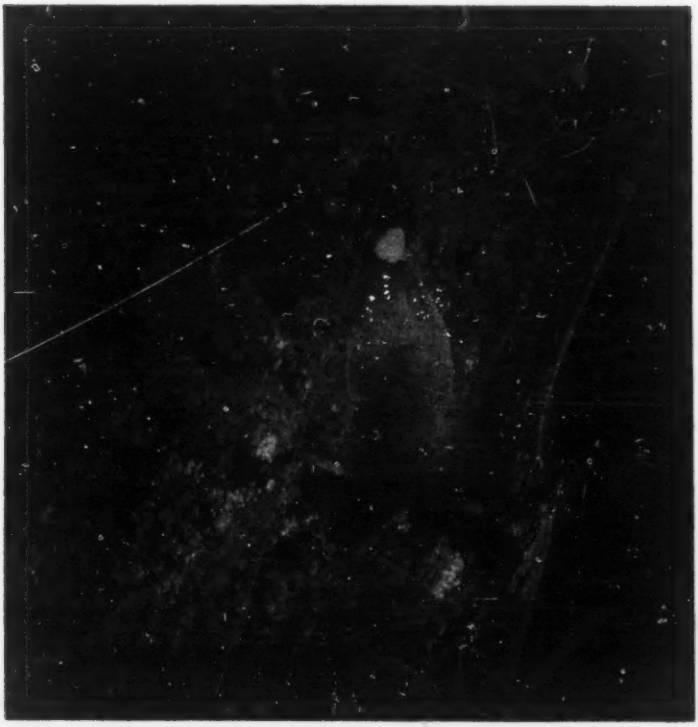

FIGURE 4

This is off the Southwest Coast of Africa. It's off the "Skeleton Coast," the "Skeleton Coast" being called that because so many ships were stranded there in the Middle Ages. And that's probably the reason the United States was—or the Americas were discovered, as people didn't want to sail around Africa and so they tried going across.

But this is a plankton bloom, microscopic organisms that live in the sea. It's in the Benguela Current, which is a current from the Antarctic that comes up along the coast and is blooming there out in the ocean. We have seen that in the Falkland Current, in the Benguela Current, and in others. And of course, obviously, scientists are very interested in how these sorts of things happen and when they happen. And this is a perspective that you just can't get from a ship or an aircraft.

Next slide, please (fig. 5).

FIGURE 5

This is in the Middle East.

And would you see if you can focus the slide a little bit better?

I think it shows there are two items that you can see. One is that you can see the wind streaks that are coming off of the islands, showing how the atmosphere interacts.

And second, if you look very close, in the center island, just up to the top, you see some things that look like little ripples. And the ripples are actually waves, not on top of the ocean but within the body of water; and it shows that water is flowing. And the oceanographers are terribly interested in this sort of documentation, because we are now finding that the ocean is not just one big mass with these massive currents flowing around. There are also smaller currents, like there are atmospheric—small atmospheric disturbances.

There are not only trade winds that flow in our atmosphere, but there are thunderstorms and fronts. And we think and are learning that there are the same kinds of things in the ocean, which are very important.

Next slide (fig. 6).

FIGURE 6

Speaking of the atmosphere, in attachment C, Northwest of Australia, this was a developing storm. It dissipated, but we tracked it and photographed it for a couple of days. And this is just one of the weather-type phenomena that we're able to see. We have, on previous manned missions, actually had people take pictures with telescopic cameras down into the eyes of hurricanes—again, something that's very difficult to document from the ground.

Try one more. That may be the last one. [Pause.]

That's it.

I'll turn it back over to Rhea. [Applause.]

Dr. SEDDON. I'd like to just say a few words about the things that we feel that we accomplished on this flight.

There were a number of firsts, but I think the most significant of those—we had the first contingency EVA, the first unplanned space walk, in which people were asked to do something that they really had never done before, although they had some background training. We had the first contingency rendezvous. We didn't really plan to do something like that. We had had some training for it, but not for this mission. We had the first unrehearsed satellite repair attempt. We've tried to fix satellites and broken pieces of equipment before, but we had always planned it out well ahead of time. And this time all the planning had to take place while we were in space and the planners were here on the ground.

It was also the first time that a Government official had flown in space. Senator Garn has oversight responsibility for NASA's

budget, he was assigned to our flight about 2 months before we flew, and we tried to show him what NASA was all about.

I think that our mission says something about the maturity of the shuttle system, about the confidence that we have in the crews that fly it, and the crews on the ground that plan it and take care of us while we're up there.

It showed that we were able to carry out just about any task that the ground could think up for us to do and then some. It says that we can carry multiple types of payloads on the shuttle. We did satellite deployments; we did medical experiments; we produced a commercial product; we produced a film for education for young children; we observed the atmosphere, the sea, and the land.

I think the shuttle is a remarkable platform for all of these tasks, and I think it's capturing the imagination of potential customers. It says that we can carry nonastronauts aboard who have either a payload to operate or a job to do that's important for the shuttle's future. It says we're willing to let someone with oversight responsibility watch what we do at NASA, without changing anything that we do, without modifying the whole program to try to impress someone. Everything we do at NASA we're proud of, and we're willing to show it to anyone who would like to see it. It showed the teamwork that NASA is famous for, and I think it showed it at its best. I think that Bo and I and the rest of the crew are proud and honored to have been a part of Shuttle Flight 51-D.

Thank you. [Applause.]

And I think, for the Congressmen who were kind enough to come and join us here in Middle Tennessee, Bo and I have a couple of things that we would like to present to you. [Pause for presentation.] [Applause.]

Mr. GORDON. As exciting as those films were, anyone that was there at the launch—and I know many of you were—can tell the others that there's no way to really express the enormous amount of power that's generated when that rocket takes off.

Now, we were probably 1 mile away and could just feel it rumble through us.

Now we'd like to have a few questions.

Rhea, with your background in medicine, would you tell us, please, what you think is the potential for the commercialization of space in the area of medicine?

Dr. SEDDON. The continuous-flow electrophoresis experiment—or "system," as it now is called, because it's no longer an experiment—is a good example of how an engineering firm, McDonnell Douglas, and a drug company, Johnson & Johnson, have worked together with the people at NASA to try and find a way of purifying medications and products that can't be done here on the ground. And that's for the benefit of everyone.

It shows a way that we can use the shuttle to produce something that's going to pay us back for flying it in space. But I think, also, we are learning more about the human body from experiments like the American flight echo, in understanding how the human body reacts to gravity, because we can understand how it reacts when we take that gravitational force away. I think it's important in understanding a number of the disease processes that we see here on the ground, like the loss of calcium that women experience as they

get older—how does gravity affect that? How can you improve what gravity does so that those illnesses don't happen anymore?

There are multiple ongoing life sciences experiments that I think will show very interesting results in the future. I am privileged to be aboard a life sciences flight that will go next year, and I think there are going to be many breakthroughs in the field of medicine in the future.

Mr. GORDON. Have you had a chance to determine yet the results of this electrophoresis purification program at this time?

Dr. SEDDON. Charlie Walker, who worked the electrophoresis experiment this time, was doing sample assays and also assays for biological contaminants during the flight. He could find nothing during the flight. He felt that he got a pure product out at the end that was not contaminated. And as soon as they can get a sufficient quantity of that—and they believe they did from this flight—they will begin testing by the Food and Drug Administration so that we can produce this in quantity in the future and begin giving it to people.

Mr. GORDON. What specific drugs do you think would be the most likely to be the best place to start?

Dr. SEDDON. There are a number of suggestions. And of course, Johnson & Johnson is keeping the actual product from each flight that they go on a secret. But there are some potential drugs—for instance, growth hormone, interferon, which fights off viral infections. They also are able to purify cells—in other words, take a large group of cells and pick out the ones that produce a certain hormone, such as the beta cells, which produce insulin in the pancreas. There are drugs like erythropoietin, which is a chemical produced by the kidney that actually tells the body to manufacture red blood cells.

So, they have an awful lot of things in mind, and I think they're proving that the system works better than they ever thought it would.

Their next step is to take not a small system that sits in the middeck, but a large vat of material that sits out in the cargo bay and produces these chemicals in great quantity. They think it's going to be profitable because they have invested in it and NASA has helped them to be able to do this because we hope that other companies, when they see the profit that's made from this sort of endeavor, will invest in it in the future.

Mr. GORDON. What about the potential though for cancer research?

Dr. SEDDON. I think that drugs are going to be produced through this sort of system that may help us in cancer research. There was an interesting experiment that flew last year called the—I believe it flew on Bo's flight, that produced small spheres—tiny, tiny spheres of latex that we hope to apply medications to the outside of that will get into the blood stream and go to specific cancer areas. So, I think that there are a number of small experiments that perhaps the public doesn't really hear much about, because when you say, "We're making small latex spheres," you know, people say, "Why would you want to do that?"

But there is a reason for it, and NASA is very careful about flying only experiments that have the potential for great benefit to

the human race aboard the space shuttle. And we're seeing more and more of them.

Mr. GORDON. I think that's an exciting part of the program.

We've got a couple of teachers here that hope that one of them will be an astronaut in the future, and I suspect there are several students here that would like to be an astronaut in the future.

What does the hometown product think about their prospects and what should they be doing?

Dr. SEDDON. Well, I think there are a number of things that you have to do to become an astronaut—I think the most important of which is to get the best education possible and pursue your education for as long as possible. The pilot astronauts have to have at least a bachelor's degree in science or math, and advanced degrees are preferred. The scientist astronauts—just about all of us have advanced degrees, either on a diploma or having done education-work after college in the fields that NASA is interested in.

It's helpful to pursue a field that's pertinent to what we do with NASA, either math, science, engineering; although we're seeing people with backgrounds completely different. For instance, Senator Garn has a background in banking and finance, but NASA decided that his background and his expertise were important to this mission. I think we're going to see more and more people in the future with totally different backgrounds flying.

But I think it's important to get the best education that you can in whatever fields you choose to pursue. I think that students should also be diverse in their activities. We see that people selected for the astronaut program are not only smart in their own field but they're smart in other fields—they know about computers, they know about cameras, they know about making speeches to the public. [Laughter.]

They know about an awful lot of different things that become important as you go through the Astronaut Program. And NASA likes to see as well-rounded an individual as possible.

I think we learned from our flight—and this is a Jeff Hoffman quote—when asked what he thought was the most important characteristic he had that suited him to his flight, he said, "Patience." [Laughter.]

And because we had to wait a 1½ years to fly, we had to be very patient. But I think it showed that we were educated when we became astronauts. We were trained for three different missions. And although we had not done any of the things that we were called upon to do in almost a year, that education came back. We were well educated by NASA, and we didn't forget anything that we had learned.

Mr. GORDON. Was it 1978 that you first started in the program?

Dr. SEDDON. That's correct. It's been quite a few years that——

Mr. GORDON. Yes; that is patience.

Dr. SEDDON. I learn something new every day.

Mr. GORDON. Good.

OK. Congressman Nelson.

Mr. NELSON. Thank you, Mr. Chairman.

Preparatory to my question to Colonel Bobko—I want everybody to understand here, when you saw the film and you saw the shuttle descending, ready for landing—and you heard the colonel talk

about at 40,000 feet he took over the controls—he's flying this machine, he doesn't have an autopilot at that point, and he doesn't have any engine power. So, he can't put the throttle in and go around; he's got to be right on the money.

And of course, you were right on the money, and that is a testimony to the expertise of our shuttle astronaut pilots.

Now, there's some evidence that when you touched down you had a little bit of a crosswind and you had a little bit higher speed than what would be the normal touchdown speed, a little bit higher speed when you brought your nose down.

What were the factors that led to that higher touchdown speed?

Colonel BOBKO. The touchdown speed was possibly about 10 knots higher than what we had said was the optimum. But I think it is within the band of that to be expected.

And of course, our vehicle was really not very heavy or very—"very heavy" being the big thing. For instance, we deployed our satellites, not like this craft, which will be coming back with a spacelab on board. So, all those items were within the allowable sink rate and speed of touchdown.

Mr. NELSON. Now, was the increased 10 knots—did that put the extra stress on the brakes, or was it a factor of the crosswind or what?

Colonel BOBKO. Oh, that's still being analyzed. Certainly, it was the right tire that blew, and the evidence points to the fact that it was my holding the brake because of the right crosswind that heated up the brake and finally caused it to fail, which caused the tire to rub on the rough surface of the runway and blow.

Mr. NELSON. What are the prospects, now that the Syncom satellite is up there and the timing mechanism hasn't activated—what are the prospects that we would want to take the risk of going back up there and trying to change out some instrumentation in the midst of all of that explosive potential there and try to get the thing working?

Colonel BOBKO. Well, you know, sir, that's something that's being carefully evaluated by an awful lot of people. And we are progressing along a front of some people figuring out how to do it, while others figuring out whether or not it's too dangerous. And that decision hasn't been made yet. And I imagine there will be a lot of long meetings with a lot of managers late at night trying to figure out whether we should try it and whether there is really any danger.

Mr. NELSON. Well, following that, Rhea, since you're the expert with the remote manipulator arm, do you have any recommendations as to how you could redesign satellites so that if you had that particular kind of malfunction that you'd be able to go over there and just tap it here and there and we would have the problem solved?

Dr. SEDDON. I have an even better idea. I think NASA is now thinking about it, because we occasionally do have a satellite that malfunctions and we'd like to be able to do something to fix it, whether there is the capability—We have to pick it back up and put it in the cargo bay and bring it home if it doesn't work right or whether it's the potential of going in and having someone, as we hope with Syncom, reactivate it.

It would be very helpful for people who are operating the arm to have what we call a grapple fixture on these satellites. It's a target with a small post that sticks up that the arm can grab ahold of. There came the question during our flight—and I think in the possible, as they're calling it now, "resurrection mission" for the future for Syncom—we came up with the problem that there's nothing to grab onto on Syncom.

If we had wanted to hold it still, to do something to it, for an EVA crewman to hold onto, what we'd have to do is put a man on the end of the arm who could reach out and grab that satellite. NASA decided that was a very dangerous thing for us to do on this mission, because we didn't feel that we knew enough about the satellite, that we felt trained enough to do that with a person on the end of the arm, that it was safe enough for us to carry out at this point in time. If the Syncom had a grapple fixture on it, if we'd been trained to grab that grapple fixture with the arm, I think it would have been a much simpler task. Certainly, anyone who goes back up there to do something to that satellite is going to have the problem of getting it stabilized so it can be worked on.

And I think NASA ought to consider asking its customers if they have any thought that maybe their satellite will have to be repaired, returned, refurbished in some way, that they put a small fixture on the side of it so it's an easier thing for us to handle.

Mr. NELSON. Would it be useful to you if you had a video linkup with the ground so that when they said, "Go over there and take that window shade and make a fly swatter," that they could show you a picture of how they were making a fly swatter down in Houston while you're trying to make it up there, 250 miles up in space.

Dr. SEDDON. It certainly would. I think our most puzzled looks came when these instructions came up. And NASA was very creative in sending us computer-generated pictures of the "fly swatter," of the separation switch that we were supposed to hit. But you never quite know, when someone sends up a batch of words, that what you're building is actually what they want you to build.

And so we put the "fly swatter" and the "lacrosse stick" together partway, and then we're able to show it to them and discuss with them exactly what they wanted and how they wanted us to modify the things that we had built.

NASA has the capability of producing graphics, sending up pictures to the shuttle, when we get one of our tracking and data relay satellites completely functional.

We have what's called a text and graphics system that we certainly hope that we can use in the future. It won't send us television pictures, but at least it will send us photographs; and I think that will help us quite a bit. There are many times during a mission when someone has to arm-wave on the ground and try and describe to you what it is they are thinking or what it is they want you to do.

Our ground people are very good about taking three or four pages' worth of instructions and words and cutting it down to the simplest instructions they think make things clear. But one picture is worth, in our way of thinking, many thousand words.

Mr. NELSON. Mr. Chairman, just one more question.

I want to ask Colonel Bobko—you said you sustained, apparently, more damage upon return than has been normally the case.

And just so that everybody knows, that we're not talking about a lot of damage, but we saw some dings, some nicks on the thermal protection system, the silicon tiles, and on the skin of the orbiter.

And you had some tiles that were lost in the vicinity of the elevon. Could you help our committee understand what might be the problem and what you think we need to do about it?

Colonel BOBKO. Normally, if we have dings on the tile, those occur during the ascent. What typically happens is that during the time you're going up through the atmosphere small pieces of ice break off that may have formed on the tank—or small pieces of the tank itself. Sometimes the insulation comes off.

We're still analyzing those to find out exactly when they happened. I would suspect that given the fact that there were more clouds in the area that day there may have been some more ice or something else which caused the dings on the surface of the tile. None of those things were of any consequence in the thermal protection system. We did, however, lose a couple of tiles on the outboard wing. I didn't have any knowledge of that before we came down. I think I'm glad I didn't. [Laughter.]

But those are being investigated. One theory I have heard about that was that perhaps some of the hot gas had gotten in underneath the tile, caused the bond to break down, and therefore caused the loss of that tile.

Mr. NELSON. When would that hot gas have gotten in?

Col. BOBKO. During the entry.

Mr. NELSON. During reentry?

Colonel BOBKO. During reentry.

Mr. NELSON. I see.

Colonel BOBKO. You know, it's very possible that the initial problem may have started during ascent.

See, during ascent you experience the highest atmospheric load on the shuttle. We get up to—talking in aircraft terms—a little over 500 miles an hour during the ascent, although the heat load is not great. When we're coming back, we very seldom get much over 350 miles an hour, although the heat load is much greater during the reentry. So, if you have atmospheric-related damage, it normally happens during the ascent. But, of course, it damages the tiles that are necessary, then, for the entry.

People, of course, are still studying that, and we've only been down for less than 2 weeks. So, there's still a lot of data gathering that must be done before we come to a decision.

Mr. NELSON. You didn't sense any kind of handling characteristics, the fact that you had part of that elevon burned off?

Colonel BOBKO. No; of course, we're talking about a piece that's—they talk about a pie-plate sized piece.

Mr. NELSON. I see.

Colonel BOBKO. And it didn't ever burn the elevon off. It did do some damage to the aluminum structure of the elevon. But it was essentially a hole there. I didn't know that it was there.

Mr. NELSON. Thank you, Mr. Chairman.

Mr. GORDON. Thanks to Carl Buckner and John Hodge Jones, we've had several students that are here today. We have a repre-

sentative from all the students in Rutherford County. And they have prepared some questions. We can't ask them all, but we want to ask some of the questions that these students have presented.

And Colonel Bobko, I think this is a good one here. This is from Smyrna Elementary School.

The question is: "Why is it important to spend so much money studying space? We have so many people that are starving here on Earth."

Colonel BOBKO. Well, you know, we aren't studying space only. We study the Earth, as some of these photographs showed you. In one instance, we were asked to photograph the Sahel, which is that area in Africa which is just below the Sahara Desert that is drying out and causing people to starve. So we got a whole row of photographs along the Senegal River, which is one of the areas of interest. And of course it's only from space that you can document how that large area is changing in its vegetation.

We have unmanned satellites that document that, as well as our own photographs. But it is the hand-held high resolution photography that helps us interpret what we get from the other photographs. So, in this particular instance, we're interested directly in how the Earth is responding to this drought, because we're interested in the people there and how they may be subjected to the starvation that we all know so much about.

Mr. GORDON. Do you want to add anything to that, Rhea?

Dr. SEDDON. No. I think that we're learning how we can use the shuttle to help people here on the ground. I think that's one of its important tasks, in understanding how the world reacts to all of the things that happen in the atmosphere, in the sea, on the ground. And I think if we spend all of NASA's budget, we could feed a few hungry people for a few days, but it wouldn't help solve the total problem. I think we need to take a bigger view so that we can help more people.

Mr. NELSON. Mr. Chairman, I might add that already our Space Program has produced weather satellites that directly relate to agricultural production.

The Landsat technology that can determine where crop disease is from photography in space, infrared photography, that has enormous application to agricultural production already.

And as our two astronauts have suggested, with a trained eye in space, as well as trained photography, regular photography, we're learning all kinds of things about this spaceship Earth that we didn't know before that has direct application to our living here.

Just the technology spinoffs in the area of medicine—Rhea's specialty—are just phenomenal.

But the question was: What, in space, should we be doing there, when, in fact, we could be using that money for starvation here on Earth, when already we're a lot better as a result of America's space program?

Mr. GORDON. I know you have a special interest—you didn't know that question was coming up. But Bill Nelson and his wife recently went to Ethiopia and personally looked at the terrible problem and starvation there and have made a personal commitment, outside of his offical duties, to try to raise money, to try to get people interested in that.

And I think that, you know, these can go hand in hand.

One last question, Rhea, from Carrie Jakes—she's from Readyville—and is it Mr. Brandon's sixth grade class out at Kitrell.

And she wants to know: "What was discovered from the cardiovascular and motion sickness test run on Senator Jake Garn and how will this information help on future flights?"

Dr. SEDDON. Well, Senator Garn had the—was good enough to not only fly aboard the shuttle to watch what we do, but to volunteer to do some of the experiments that we were interested in in the field of motion sickness. It's very difficult to talk astronauts into doing studies that might provoke motion sickness, because we have so many important things to do.

Usually, the motion sickness problems that we have are in the first 2 days when we get into space, and those are typically the busiest 2 days that you have during the mission. Not only do you have satellites to deploy, but you have to get use to working in space, you have to set up all of your equipment. So it's very difficult to talk astronauts into doing extra medical experiments during that timeframe.

Senator Garn volunteered for these things, many tests that had never been done on anyone before in space. We don't have the results back. Senator Garn was very straightforward in saying he was sick the first 2 days of the flight; and so we have a sick crewman who we instrumented heavily, and I think we're going to see what the connection is between being in zero gravity and having some form of motion sickness.

It doesn't seem to correlate with motion sickness here on the ground. I probably have the weakest stomach of the crew and yet didn't have many problems when I got up there. But we'd like to understand that better so people can be efficient those first couple of days up there. The results are not in yet, and it's only one test subject. But I think it will help us design experiments in the future that will help us prevent this kind of problem.

The cardiovascular experiments—again, we're just analyzing that data. Luckily, we had four crewmen that were volunteers for that. It was a rather simple thing for them to stand while I echoed their heart. Senator Garn had an excellent heart for this. He's a very athletic gentleman, and he had a very large heart. I was much appreciative of his efforts in getting good data for that experiment.

Again, it will just begin to show us what happens, it will help us design experiments in the future, and it will help us apply what we find to disease processes that we find here on the ground, too.

Mr. GORDON. Well, Sarah King has taught me to stay on time, and for that reason, we're going to have to adjourn this hearing at this time.

[Whereupon the subcommittee was adjourned.]

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